AN ARTIFICIAL DIET FOR MAINTAINING LADYBIRDS

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Introduction

Considerable interest has been shown in ladybirds over the past twenty-five years or so, due to their potential economic use for the biological control of agricultural pests such as Aphids and Coccids. However, one of the main problems associated with the study of ladybirds in the laboratory throughout the year, and the rearing of large numbers of individuals for biological control, is the provision of sufficient food. This, at its most basic, would involve the mass rearing of the prey species on a suitable host plant. This technique, however, suffers from the disadvantages that (i) the rearing of the prey species in large numbers is wasteful of space, labour and, in consequence, money, (ii) failure of the prey population due to disease or accident could lead to partial or complete loss of the ladybird population.

To cope with these problems, several workers have attempted to develop alternative foods, either to replace live food, or to supplement it when required (Smirnoff, 1958; Smith, 1965 a, b, c; Bain et al, 1984). There have been basically two main approached to the preparation of artificial foods: (a) to preserve, by freezing or drying, the natural prey, or a substitute species, which may then be fed, either alone, or mixed with other ingredients, (b) to prepare a totally artificial diet without the use of live food. Experience has usually shown that, while ladybirds can be kept alive for long periods of time on artificial foods, they usually require some substance(s) only found in live food to breed successfully.

In Cambridge, we have been carrying out chromosome studies of population samples of several ladybird species. This work has been carried out in association with Drs M. Majerus and P. Kearns, who have been involved in a nationwide ladybird survey. This has often necessitated keeping ladybirds alive in the laboratory for long periods of time and attempting to breed them. Our main concern was to be able to keep adult ladybirds, of as many different species as possible, alive in the complete absence of their normal diets.

The diet published by Smirnoff (1958) appears to be an excellent recipe for maintaining ladybirds alive for long periods, but suffers from two drawbacks: (i) it uses large amounts of dried and powdered insects, which are the normal prey food of the species to be reared. These may not be readily available, or even known in some cases, (ii) it also uses large amounts of Royal Jelly. This is normally available from beekeepers only once a year, when hives are dismantled. Its current popularity as a health food makes commercial purchase of large amounts decidedly uneconomic. In 1965 Smith experimented with a

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series of artificial diets for maintaining the adults and larvae of ladybirds. Some of these involved dried, powdered aphids, others involved pollen, or other foodstuffs, quite unrelated to their normal diets, such as brewers yeast, or dessicated liver, without the use of any aphid additives.

We attempted to feed our ladybirds with Smith's dried, powdered mixture of liver, yeast and sucrose, but they did not find the powdered food acceptable. An agar-based food of the type developed by Smirnoff seemed a much more suitable food substitute and an attempt was made to develop a new artificial food combining the merits of the recipes of Smith and Smirnoff. Using a new ratio of quantities arrived at largely by intuition, the combination of dried liver, yeast, sucrose and vitamins recommended by Smith was combined with an agar jelly of the type used by Smirnoff. The honey used in Smirnoff's recipe was replaced by Maple syrup simply because we were interested in rearing species which were arboreal and had been collected from aphid-infested field maple and sycamore trees as well as their normal coniferous trees. The resulting foodstuff proved to be a complete success from the start and, apart from the addition of a small amount of the fungicide Nipagin to retard mould growth, has been used unchanged for the past three years.

Materials and Methods

(A) **Ingredients**

9g LIVER (Dried, powdered, dessicated OXOID or DIFCO)
6g YEAST (Dried, powdered)
15g SUCROSE (Domestic sugar satisfactory)
2g AGAR (powdered)
2 MULTIPLE VITAMIN PILLS (Crushed: e.g. BOOTS)
10ml. MAPLE SYRUP (pure)
150 ml. Water (Distilled)

Optional Extra: 1-2 ml. NIPAGIN solution (stock solution: 10% w/v in absolute ethanol)

Suppliers (U.K.):
1.Oxoid dessicated liver, Code: L26 (500g); Oxoid Ltd., Wade Road, Basingstoke, England RE24 0PW.
2. Boots Plurivite Multivitamin Tablets: from Boots Chemist Shops, or The Boots Company, Nottingham, England.
3. Nipagin (500g.): Nipa Laboratories Ltd., Llantwit Fardre, Nr Pontipridd, South Wales CF38 2SN.

(B) **Preparation**

1. Mix LIVER, YEAST, SUCROSE and AGAR in a large beaker and add the water. Heat to boiling, with stirring, and continue to simmer

gently until all agar is dissolved and most lumps and particles are dispersed to produce a creamy liquid. **Avoid excessive evaporation**. (A Bunsen burner or microwave oven can be used.)

2. When almost ready, add 1 - 2 ml. of the 10% NIPAGIN solution (if required), and continue to heat for a further 1 - 2 minutes to drive off alcohol.

3. Remove from the heat, add the MAPLE SYRUP and allow to cool to circa 50°C. Add the two VITAMIN PILLS which have previously been crushed and powdered in a pestle and mortar.

4. Stir thoroughly to dissolve and disperse. Then pour into suitable containers, cover and allow to cool and set. (The quantities recommended will fill five plastic petri dishes (90mm.) to a depth of circa 5mm.)

5. Store in a refrigerator until required.

(C) **Use**

Only small pieces of food need be used. Pieces circa 1cm. square can be cut from the blocks using a small knife or scalpel. These will dry out over the course of a few days and will need to be replaced regularly. Sometimes half-dry food appears to be more attractive than completely fresh food. Ladybirds can be kept in small plastic containers such as petri dishes, but these need to be washed out and changed frequently (at least once a week), not only to avoid the build up of mould spores, but also to remove their own toxic waste products.

The unprotected food does not grow bacterial colonies because of the high sugar content recommended. But fungal growth can be rapid and cause a problem. The addition of a fungal inhibitor such as NIPAGIN reduces mould growth considerably and does not appear to be too poisonous to ladybirds at the low concentrations recommended. If in doubt, two batches should be prepared, one with fungicide and one without, and their performance compared.

Discussion

The agar/liver based artificial food described in this paper has been successfully used in maintaining the adults of many different species of ladybird and their larvae for the past three years. We ourselves have been mainly concerned with the Chilocorids, while Dr Majerus and his co-workers in this Department have successfully fed many of the other British species of ladybird on this food, and several species sent from overseas also.

Because it has proved so successful from the start we have had very little incentive, or time, to experiment with the recipe to try to improve it. It is quite possible that improvements could be made by changing

some of the ingredients, or their concentrations. Modifications would almost certainly improve its performance with different species and the addition of powdered host (Aphid or Coccid) material, as recommended by Smirnoff (1958) might also help with some species. One should feel free to experiment, as we have done, using the present recipe as a starting point.

We have noted differences in its usefulness with adults and larvae of the same species. Thus, adults of *Exochomus quadripustulatus* and fully grown larvae accept the food with no difficulty and adults can be kept alive for almost 12 months on this artificial food alone, with no live food. The younger instars of *Exochomus*, however, find this food toxic and die soon after eating it. Similarly, adults of *Anatis ocellata* have been kept alive for 12 months on this food alone. *Anatis* larvae can be reared through to adults fed from early instars on this food (in the individual containers to avoid cannibalism), but larval secretions, or waste products, turn the food blocks black, and they should be changed every 1 - 2 days.

Although many species of ladybird can be kept alive for long periods of time on this food alone, they usually do not show mating behaviour unless their diet is supplemented by some live food. Of the species we have tried with this food, the one least interested in eating it in its present form is *Cryptolaemus montrouzieri*. This is unfortunate, in view of the widespread use of this ladybird in biological control programmes. No doubt changes could be made to the recipe to make it more acceptable to this species.

Other carniverous beetles and even Hemipterans have been fed with this artificial food and have found it acceptable. It is quite likely that variations of this recipe could be of wide applicability for the mass culture of carniverous insects in general, should the need arise.

References

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